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Request for grant of a patent

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13 SEP 2000

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1. Your reference — P.80540 MN/MPR

2. Patent application number *(The Patent Office will fill in this part)* — **0022479.0**

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

1... IPR Limited
St John's Innovation Centre
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CB4 0WS

Patents ADP number *(if you know it)* 7803697001

D00192

If the applicant is a corporate body, give the country/state of its incorporation — United Kingdom

14SEP00 E568088-1 [redacted]
P01/7700 0.00-0022479.0

4. Title of the invention — AUDIO PLAYBACK SYSTEM

5. Name of your agent *(if you have one)* — J A KEMP & CO

"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

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LONDON WC1R 5LX

Patents ADP number *(if you know it)* 26001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer "Yes" if:*
a) any applicant named in part 3 is not an inventor, or
b) there is an inventor who is not named as an applicant, or
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Continuation sheets of this form	-
Description	6
Claim(s)	3
Abstract	-
Drawing(s)	1+H

10. If you are also filing any of the following, state how many against each item.

Priority documents	-
Translations of priority documents	-
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	-
Request for preliminary examination and search *(Patents Form 9/77)*	-
Request for substantive examination *(Patents Form 10/77)*	-
Any other documents *(please specify)*	-

11. I/We request the grant of a patent on the basis of this application

Signature J.A. Kemp Date 13 September 2000

J.A. KEMP & CO.

12. Name and daytime telephone number of person to contact in the United Kingdom

M P ROBERTS
020 7405 3292

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AUDIO PLAYBACK SYSTEM

This invention generally relates to a method for reproducing an audio signal received at a reproducing device. The invention is more particularly applicable to devices which steer the audio output signals so that they are transmitted mainly in one or a plurality of separate directions.

Systems using a phased array of transducers can be operated so as to direct an audio signal in a particular direction. This is achieved by subjecting the audio signal fed to each transducer by a delay. The amount of delay observed at each transducer determines the direction in which the audio signal is directed. It is therefore necessary for an operator of such a system to program the device so as to direct the signal in a particular direction. If the desired direction changes, it is necessary to reprogram the device.

The present invention seeks to alleviate the above problem by providing a method and apparatus which can direct an output audio signal automatically.

This is achieved by providing an information signal associated with the audio signal, the information signal comprising information as to where the audio signal should be directed at any particular time. Thus, every time the audio signal is played back, the associated information signal is decoded and is used to direct the audio signal. This dispenses with the need for an operator to program where the audio signal must be directed and also allows the direction of audio signal steering to be changed as desired during reproduction of the audio signal.

In particular, the present invention provides a method of reproducing an audio signal, said method comprising:

decoding an information signal associated with said audio signal:

processing said audio signal according to the information signal decoded in said decoding steps:

reproducing said processed audio signal.

Furthermore, the present invention provides a method comprising:

deciding on physical location at which said audio signal should be directed during reproduction; and

coding said information signal according the result of said decision.

The present invention also provides a device for reproducing an audio signal comprising:

an input terminal for inputting an audio signal;

an input terminal for inputting an information signal;

means of replicating said audio signal n times and delaying each of said n replica audio signals by certain amount;

means of decoding the information signal;

means of obtaining the certain delay amounts for each of said n replica audio signal according to the decoded information signal; and

means for transmitting each of said n delayed replica audio signals to an array of transducers so that directed sound is achieved in accordance with said information signal.

Still further, the present invention provides a decoder comprising:

means to interface with a conventional output transducer driver;

means to receive a plurality of audio signals and a plurality of associated information signals;

means for decoding said information signal and using the results of said decoding to route said audio signals to said output transducer driver such that a desired directional effect is achieved with conventional output transducers.

The present invention will be further described, by way of non-limitative example only, with reference to the accompanying drawing which shows a device in according with an embodiment of the present invention.

The invention is a sound playback system capable of reproducing one or several audio channels, some or all of which of these channels have an associated stream of time-varying steering information, and a number of loudspeaker feeds. Each stream of steering information is used by a decoding system to control how the signal from the associated audio channel is distributed among the loudspeaker feeds. The number of loudspeaker feeds is typically considerably greater than the number of recorded audio channels and the number of audio channels used may change in the course of a programme.

The present invention applies mainly to reproducing systems which can direct sound in one of a number of directions. This can be done in a plurality of ways:-

- Many independent loudspeakers may be scattered around the auditorium and directionality may be obtained by simply routing the audio signal to the loudspeaker nearest to the desired location, or through the several nearest loudspeakers, with the levels and time delays of each signal set to give more accurate localisation at the desired point between speakers;

- A mechanically controllable loudspeaker can be used. This approach can involve the use of parabolic dishes around conventional transducers or an ultrasonic carrier to project a beam of sound. Directionality can be achieved by mechanically rotating or otherwise directing the beam of sound; and

- Preferably, a large number of loudspeakers are arranged in a (preferably 2D) phased array. Each loudspeaker is provided with an independent feed and each feed can have its gain, delay and filtering controlled so that beams of sound are projected from the array. The system can project beams to a particular point or make sound appear to come from a point behind the array. A beam of sound may be made to appear to come from a wall of the auditorium by focussing a beam on that wall.

In accordance with the described embodiment, most of the loudspeaker feeds drive a large, two-dimensional array of loudspeakers, forming a phased array. There may also be separate, discrete loudspeakers and further phased arrays around the auditorium. The phased array is driven by providing that a delayed version of the same audio signal is provided to each individual loudspeaker. The driver therefore typically replicates the input signal a number of times and delays each replica by different amounts according to the effect to be acheived.

Sound signals are given directionality by providing that the input to each of the loudspeakers of the phased array are delayed by different amounts. Further, the

gains of such signals may be adjusted to provide for some degree of beam shaping and the signals may be filtered to provide, for example, that different frequencies are directed in different ways.

The present invention comprises associating steering information with the actual audio signal itself, the steering information being useable to dictate how the audio signal will be directed.

The steering information may consist of the delays to be provided to each replica of the audio signal. However, this approach leads to the steering signal comprising a lot of information.

The steering information is preferably multiplexed into the same data stream as the audio channels. Through simple extension of existing standards, they can be combined into an MPEG stream and delivered by DVD, DVB, DAB or any future transport layer. Further, the conventional digital sound systems already present in cinemas could be extended to use the composite signal of the present invention.

Rather than using steering information which consists of gains, delays and filter coefficients for each loudspeaker feed, it can instead simply describe where the sound is to be focussed or to appear to have come from. During installation in an auditorium, the decoding system is programmed with, or determines by itself, the location of the loudspeaker(s) driven by each loudspeaker feed and the shape of the listening area. It uses this information to derive the gains, delays and filter coefficients necessary to make each channel come from the location described by the steering information. This approach to storing the steering information allows the same recording to be used with different speaker and array configurations and in differently sized spaces. It also significantly reduces the quantity of steering information to be stored or transmitted.

In audio-visual and cinema applications, the array would typically be located behind the screen (made of acoustically transparent material), and be a significant fraction of the size of the screen. The use of such a large array allows channels of sound to appear to come from any point behind the screen which corresponds to the locations of objects in the projected image, and to track the motion of those objects. Encoding the steering information using units of the screen height and width, and

informing the decoding system of the location of the screen, will then allow the same steering information to be used in cinemas with different sized screens, while the apparent audio sources remain in the same place in the image. The system ma be augmented with discrete (non-arrayed) loudspeakers or extra arrays. It may be particularly convenient to place an array on the ceiling.

Figure 1 shows a device for carrying out the invention. An audio signal multiplexed with an information signal is input to the terminal 1 of the de-multiplexer 7. The de-multiplexer 7 outputs the audio signal and the information signal separately. The audio signal is routed to input terminal 2 of decoding device 8 and the information signal is routed to terminal 3 of the decoding device 8. The replicating device 4 replicates the audio signal input at input terminal 2 into a number of identical replicas (here, four replicas are used, by any number is possible). Thus, the replicating device 4 outputs four signals each identical to the signal presented at input terminal 2. The information signal is routed from terminal 3 to a controller 9 which is able to control the amount of delay applied to each of the replicated signals at each of the delay elements 10. Each of the delayed replicated audio signals are then sent to separate transducers 6 via output terminal 5 to provide a directional sound output.

The information comprising the information signal input at the terminal 3 can be continuously changed with time so that the output audio signal can be directed around the auditorium in accordance with the information signal. This prevents the need for an operator to continuously monitor the audio signal output direction to provide the necessary adjustments.

It is clear that the information signal input to terminal 3 can comprise values for the delays that should be applied to the signal input to each transducer 6. However, the information stored in the information signal could instead comprise physical location information which is decoded in the decoder 9 into an appropriate set of delays. This may be achieved using a look-up table which maps physical locations in the auditorium with a set of delays to achieve directionality to that location. Preferably, a mathematical algorithm is used which translates a physical location into a set of delay values.

The invention also comprises a decoder which can be used with conventional audio playback devices so that the steering information can be used to provide traditional stereo sound or surround sound. For headphone presentation, the steering information can be used to synthesize a binaural representation of the recording using head-related transfer functions to position apparent sound sources around the listener. Using this decoder, a recorded signal comprising the audio channels and associated steering information can be played back in a conventional manner if desired, say, because no phased array is available.

In this application, an "auditorium" has been referred to. However the described techniques can be applied in a large number of applications including home cinema and music playback as well as in large public spaces.

The above description refers to a system using a single audio input which is played back through all of the transducers in the array. However, the system may be extended to play back multiple audio inputs (again, using all of the transducers) by processing each input separately and thus calculating a set of delay coefficients for each input (based on the information signal associated with that input) and summing the delayed audio inputs obtained for each transducer. This is possible due to the linear nature of the system. This allows separate audio inputs to be directed in different ways using the same transducers. Thus many audio inputs can be controlled to have directivity in particular directions which change throughout a performance automatically.

CLAIMS

1. A method of reproducing an audio signal, said method comprising:

decoding an information signal associated with said audio signal:

processing said audio signal according to the information signal decoded in said decoding steps:

reproducing said processed audio signal.

2. A method according to claim 1 wherein said decoded information signal is a sound beam steering signal intended to represent where said audio signal should be directed.

3. A method according to claim 1 or claim 2, wherein said processing comprises replicating said audio signal n times; and

delaying each of the n replica signals by a certain amount.

4. A method according to claim 3, wherein said step of reproducing said processed audio signal comprises feeding each of said n replica signals to a respective transducer of a phased array so that directed sound is achieved in accordance with said information signal.

5. A method according to claim1 or claim 2, wherein said step of reproducing said processed audio signal comprises feeding said audio signal to a transducer and pointing that transducer at a particular location so that directed sound is achieved in accordance with said information signal.

6. A method according to claim 3 or claim 4, wherein each of said certain delay amounts are obtained from said information signals.

7. A method according to claim 3 or claim 4, wherein each of said certain delays amounts are calculated using an algorithm and said information signal comprises a 3D or 2D co-ordinate.

8. A method according to claim 3 or claim 4, wherein each of said certain delays amounts are calculated using a look-up table and said information signal comprises an address in said look-up table..

9. A method according to claim 8, wherein said look-up table comprises a database relating a certain physical location with a set of delay values, said information signal comprises information indicating a certain physical location and

said processing step comprises delaying said n replica audio signals by amounts determined from the entry in the look-up table associated with the certain physical location indicated in the information signal.

10. A method according to claim 8 or claim 9, further comprising the step of calculating the look-up table by creating an association between certain physical locations and a set of n delay amounts for each physical location, said step of calculating the look-up table being performed before said step of decoding an information signal.

11. A method according to any one of the preceding claims, wherein said information signal is multiplexed with said audio signal.

12. A method according to claim 11, wherein said information signal and said audio signal are both digital signals and are time division multiplexed.

13. A method comprising:

deciding on physical location at which said audio signal should be directed during reproduction; and

coding said information signal according the result of said decision.

14. A method according to claim 13 further comprising:

associating said information signal with said audio signal.

15. A method according to claim 13 or claim 14, wherein the step of coding said information signal comprises mapping the physical location decided on to a set of n delay coefficients and coding the n delay coefficients in said information signals.

16. A method according to claim 13 or claim 14 wherein said step of coding said information signal comprises:

associating a location code with the physical location decided upon and coding this location code into the information signal.

17. A method according to claim 8 or any one of claims 13 to 16, wherein said physical location is determined relative to the output transducer(s) to be used during reproduction of the audio signal.

18. A method according to claim 8 or any one of claims 13 to 16, wherein said physical location is determined relative to a screen in a room in which the output

transducer(s) used during reproduction of the signal are located

19. A device for reproducing an audio signal comprising:

an input terminal for inputting an audio signal;

an input terminal for inputting an information signal;

means of replicating said audio signal n times and delaying each of said n replica audio signals by certain amount;

means of decoding the information signal;

means of obtaining the certain delay amounts for each of said n replica audio signal according to the decoded information signal; and

means for transmitting each of said n delayed replica audio signals to an array of transducers so that directed sound is achieved in accordance with said information signal.

20. A device according to claim 19 further comprising a de-multiplexer connected to said audio signal input and said information signal input so that a signal obtained by multiplexing an audio signal and an information signal may be input into the device.

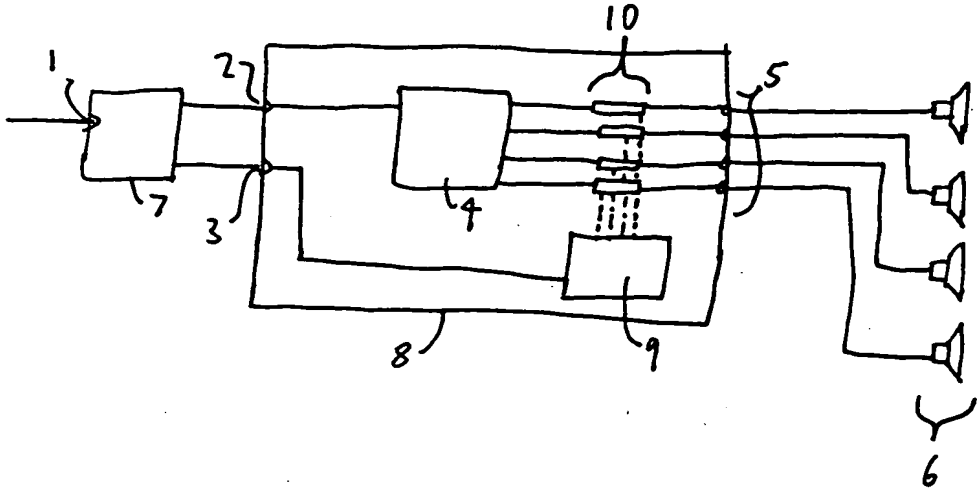
21. A decoder comprising:

means to interface with a conventional output transducer driver;

means to receive a plurality of audio signals and a plurality of associated information signals;

means for decoding said information signal and using the results of said decoding to route said audio signals to said output transducer driver such that a desired directional effect is achieved with conventional output transducers.

22. A decoder according to claim 21 which is suitable to be used when said output transducers comprise head-mounted loudspeakers.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Clare Lyons